CLAIMS

1. A field emission type electron source device comprising:

a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

the drain region includes at least two wells having different impurity concentrations; and

of the at least two wells, one well having a low impurity concentration is provided at an end of the drain region which contacts a channel region of the field effect transistor portion.

2. A field emission type electron source device according to claim 1, wherein as the impurity elements the drain region includes at least two n-type impurity elements having different thermal diffusion speeds in the silicon substrate.

3. A field emission type electron source device according

to claim 1, wherein as the impurity elements, the drain region includes phosphorous, having a fast thermal diffusion speed and arsenic, having a slow thermal diffusion speed in the silicon substrate.

4. A field emission type electron source device comprising:

a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

the gate electrode of the field effect transistor portion has a shape including portions having at least two different gate widths; and a part of the gate electrode is provided in such a manner as to cover an end of the drain region.

5. A field emission type electron source device comprising:

a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via a first insulating film and having an opening

portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

a gate insulating film is provided between the gate electrode of the field effect transistor and the p-type silicon substrate; the gate insulating film includes a film thinner than the first insulating film, the first insulating film being provided between the extraction electrode and the p-type silicon substrate; and the gate insulating film is buried with the first insulating film.

6. A field emission type electron source device according to claim 5, wherein the gate insulating film includes a thermally oxidized silicon film, provided by a step of thermal oxidization for sharpening treatment for sharpening a tip of the cathode portion of the field emission electron source portion.

7. A field emission type electron source device comprising:

a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening

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portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

the field emission type electron source device further comprises a shield electrode made of the same material of that of the gate electrode of the field effect transistor portion, and the shield electrode is provided in such a manner as to cover a channel region of the field effect transistor portion which is not covered with the gate electrode.

8. A field emission type electron source device according to claim 7, wherein the shield electrode is held at the same potential as that of the p-type silicon substrate, and the shield electrode has a function of blocking an external field, which is not caused by the gate electrode, from affecting the channel region.

9. A field emission type electron source device comprising:

a field emission electron source portion including an extraction electrode provided on a p-type silicon substrate via an insulating film and having an opening

portion at a position corresponding to a region where a cathode is provided; and a cathode portion provided on the p-type silicon substrate and at a position corresponding to the opening portion of the extraction electrode; and

an n-channel field effect transistor portion provided on the p-type silicon substrate, corresponding to the field emission electron source portion,

wherein:

the field emission electron source portion is provided in a drain region of the field effect transistor portion; and a control voltage is applied to a gate electrode of the field effect transistor portion to control a field emission current from the field emission electron source portion;

the drain region of the field effect transistor portion is provided in a source region of the field effect transistor portion in such a way to be surrounded by the source region; and

the gate electrode of the field effect transistor portion is positioned symmetrical in a plane with respect to the cathode portion of the field emission electron source portion.

10. A field emission type electron source device according to claim 9, wherein the drain region includes a p-type conductive layer.

11. A field emission type electron source device according to claim 9, wherein an outer portion of the drain region contacts the channel region of the field effect transistor portion; and the outer region of the drain region and an inner portion of the source region have a shape of concentric circles.

12. A field emission type electron source device according to claim 9, wherein at least a part of the gate electrode provided between the source region and the drain region has a shape of a symmetrical circular arc.

13. A field emission type electron source device according to claim 9, wherein first voltage Vex applied to the extraction electrode of the field emission electron source portion and second voltage Vg applied to the gate electrode of the field effect transistor portion have a relationship such that Vg<Vex.

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